

CLAIMS

1. A method for repairing and/or waterproofing and/or insulating and/or reinforcing and/or restoring the structural integrity of wall systems, characterized in that it consists:
  - 5 -- in providing spaced injection holes (3) within a wall system (1) in a manner suitable to pass through cavities (2) that exist in the wall system (1);
  - in inserting injection tubes (4) in said injection holes (3);
  - in injecting in said injection holes (3), through said injection tubes (4), a substance (5) that expands after injection as a consequence of a chemical reaction.
- 10 2. The method according to claim 1, characterized in that during injection said injection tubes (4) are retracted gradually, in the opposite direction with respect to insertion, along the corresponding injection holes (3) in order to allow said substance (5) to penetrate the cavities (2) crossed by, or proximate to, said injection holes (3).
- 15 3. The method according to claim 1, characterized in that said injection holes (3) are formed substantially at right angles to the largest surface of the cavities (2) inside the wall system (1).
4. The method according to one or more of the preceding claims,  
20 characterized in that said substance (5) is constituted by a closed-cell polyurethane foam.
- 25 5. The method according to one or more of the preceding claims, characterized in that said substance (5) is constituted by an MDI isocyanate and a mixture of polyols.
6. The method according to one or more of the preceding claims, characterized in that said substance (5) has a maximum expansion pressure substantially comprised between 20 kPa and 200 kPa.
- 30 7. The method according to one or more of the preceding claims, characterized in that said substance (5) has, during expansion, a reduction in the maximum expansion pressure, i.e. a dissipation after a degree of

expansion thereof that may be less than 5% of its initial volume.

8. The method according to one or more of the preceding claims, characterized in that said substance (5) has a maximum expansion pressure that is lower than the bursting limit pressure of the wall system in which it is  
5 injected.

9. The method according to one or more of the preceding claims, characterized in that the reaction times of said substance (5) are comprised between 3 and 60 seconds.

10. The method according to one or more of the preceding claims, characterized in that the process of chemical reaction for expansion and said substance during expansion remain non-altered by water presence.

11. The method according to one or more of the preceding claims, characterized in that said substance (5), once expanded and consolidated, maintains a non-altered state in the presence of water, or water containing  
15 acid and/or water rich in sulfates and/or carbonates or salts in general.

12. The method according to one or more of the preceding claims, characterized in that said substance (5), once injected and hardened, has a tensile strength substantially comprised between an average of  $180 \text{ N/cm}^2$  at a density of  $200 \text{ kg/m}^3$  and  $800 \text{ N/cm}^2$  at a density of  $500 \text{ kg/m}^3$ .

20 13. The method according to one or more of the preceding claims, characterized in that said substance (5), once injected and hardened, has a compression strength substantially comprised between an average of  $200 \text{ N/cm}^2$  at a density of  $200 \text{ kg/m}^3$  and  $1300 \text{ N/cm}^2$  at a density of  $500 \text{ kg/m}^3$ .

25 14. The method according to one or more of the preceding claims, characterized in that said substance (5), prior to the beginning of the chemical reaction of expansion, has a viscosity substantially comprised between  $200 \text{ mPa}\cdot\text{s}$  and  $300 \text{ mPa}\cdot\text{s}$  at  $20^\circ\text{C}$ .

30 15. The method according to one or more of the preceding claims, characterized in that viscosity of said substance (5) passes from a value of  $200\text{-}300 \text{ mPa}\cdot\text{s}$  to a value that tends to infinity in a time interval comprised

between 20 and 150 seconds starting from the beginning of the chemical reaction of expansion of said substance.

16. The method according to one or more of the preceding claims, characterized in that said substance (5), once injected and hardened, has a 5 lower relative density than water.

17. The method according to one or more of the preceding claims, characterized in that said injection holes (3) are produced along substantially vertical directions, and in that said substance (5) is injected through said injection tubes (4) by gradually retracting said injection tubes 10 (4) upward.

18. The method according to one or more of the preceding claims, characterized in that said injection holes (3) are produced along directions that are inclined with respect to the vertical and in that the injection through said injection tubes (4) is performed while gradually retracting said injection 15 tubes (4) upward.

19. The method according to one or more of the preceding claims, characterized in that the direction of the longitudinal extension of said injection holes (3) is contained between the planes of arrangement of the two larger opposite faces of the wall system (1).

20. The method according to one or more of the preceding claims, characterized in that the distance between two contiguous injection holes (3) is substantially comprised between 0.20 m and 2.00 m.

21. The method according to one or more of the preceding claims, characterized in that the diameter of said injection holes (3) is substantially 25 comprised between 4 mm and 40 mm.

22. The method according to one or more of the preceding claims, characterized in that said injection tubes (4) have an inlet that is connected to an injection device (8) and multiple outlets (9) for the passage of said substance (5).

30 23. The method according to one or more of the preceding claims,

characterized in that the overall passage section of said outlets (9) of said injection tubes (4) is greater than the passage section of said inlet.

24. The method according to one or more of the preceding claims, characterized in that said injection tubes (4) are constituted by, or treated 5 with, lubricating material in order to facilitate their retraction during the injection of said substance (5).

25. The method according to one or more of the preceding claims, characterized in that during the injection of said substance (5) the rate of retraction of the injection tubes (4) is adjusted according to the pressure 10 and/or flow-rate of injection of said substance (5).

26. The method according to one or more of the preceding claims, characterized in that it provides means (12) for interrupting the injection of said substance.

27. The method according to one or more of the preceding claims, 15 characterized in that the injection pressure is measured by way of a pressure gauge (6) that is arranged upstream of the inlet of said injection tubes (4) and is connected to the feeding tube for injection of said substance (5).

28. The method according to one or more of the preceding claims, characterized in that the injection flow-rate is measured by means of a flow- 20 rate measurement device (6) that is arranged upstream of the inlet of said injection tubes (4) and is connected to the tube (14) for feeding the injection of said substance (5).

29. The method according to one or more of the preceding claims, characterized in that it comprises detecting the presence of said substance 25 (5) and the pressure applied thereby during expansion at regions of the wall system (1) that are proximate to the regions affected by the injection.

30. The method according to one or more of the preceding claims, characterized in that it comprises measuring the presence of said substance 30 (5) and the pressure applied thereby during expansion, in the regions of the wall system (1) that are proximate to the regions affected by the injection,

by way of piezometer pipes (13) inserted in measurement holes (15) provided in the wall system (1) at preset distances from the injection holes (3) in which said injection tubes (4) are inserted.

31. The method according to one or more of the preceding claims,  
5 characterized in that it comprises constantly monitoring during the injection of said substance (5) the movement of the wall system (1) along directions that are substantially perpendicular to the planes of arrangement of the two larger faces of the wall system (1).

32. The method according to one or more of the preceding claims,  
10 characterized in that it comprises following by way of a monitoring device with laser levels the movement of the wall system (1) along directions that are substantially perpendicular to the planes of arrangement of the two larger faces of the wall system (1).

33. The method according to one or more of the preceding claims,  
15 characterized in that it comprises preliminary interventions to limit the escape of said substance (5) from outlets of said cavities (2) that lead out of the wall system (1).

34. The method according to one or more of the preceding claims,  
characterized in that said preliminary interventions consist in performing  
20 column-type injections of a substance that expands by chemical reaction in the soil directly in the interface between the soil and the wall system (1) and/or in regions of the ground that are spaced from the wall system (1).

35. The method according to one or more of the preceding claims,  
characterized in that said preliminary interventions consist in applying a  
25 sheet of geotextile fabric (11) to the surface of the wall system (1) where said outlets of the cavities are present and in performing a spray covering of said fabric (11) with a substance (5) that expands by chemical reaction.